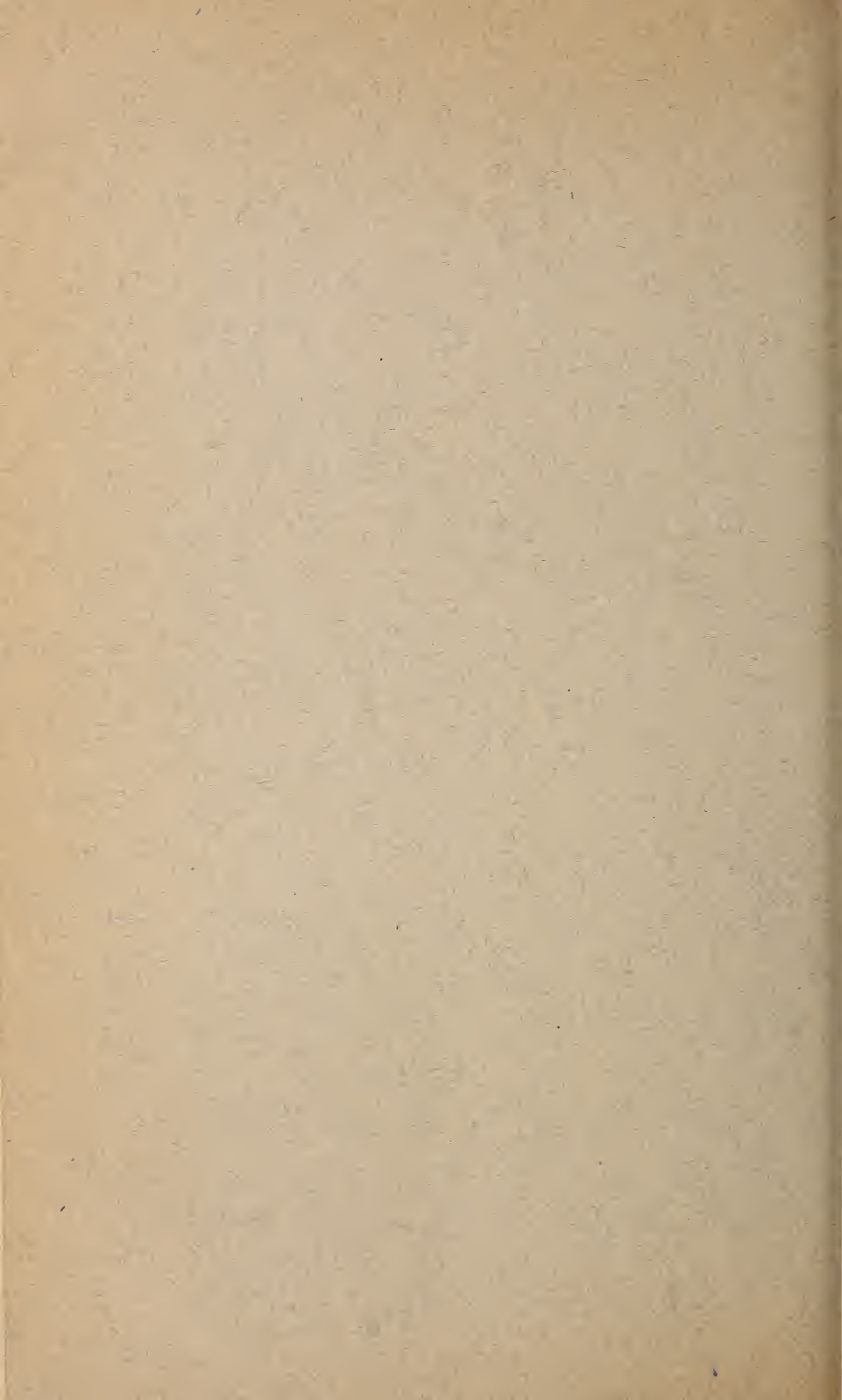


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PORTO RICO AGRICULTURAL EXPERIMENT STATION

D. W. MAY, SPECIAL AGENT IN CHARGE.

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ANNUAL REPORT

OF THE

PORTO RICO  
AGRICULTURAL EXPERIMENT  
STATION

FOR

1908.

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UNDER THE SUPERVISION OF  
OFFICE OF EXPERIMENT STATIONS,  
U. S. DEPARTMENT OF AGRICULTURE.

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SAN JUAN, P. R.  
PRESS REVIEW PRINTING CO.

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Issued September 1909

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## PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, Chief of Division of Insular Stations, Office of Experiment Stations.

---

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W. E. HESS, *Expert Gardner.*

CARMELO ALEMAR, Jr., *Stenographer.*

## LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,  
*Mayaguez, P. R., January 12, 1909.*

SIR : I have the honor to transmit herewith and recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year 1908.

Respectfully,

D. W. MAY,  
*Special Agent in Charge.*

Dr. A. C. TRUE,  
*Director Office of Experiment Stations,  
U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.  
A. C. TRUE, *Director.*

Publication authorized.  
JAMES WILSON,  
*Secretary of Agriculture.*





# CONTENTS.

	Page.
Summary of investigations .....	7
Introduction .....	7
Sugar cane .....	10
Tobacco .....	12
Coffee .....	13
Fibers .....	13
Forage crops .....	14
Live stock .....	15
Report of the horticulturist .....	17
Introduction .....	17
Inspection trips .....	18
Cooperative work .....	18
The orchards .....	18
The garden .....	20
Pineapples .....	21
Plant introduction and plant breeding .....	21
Report of the entomologist .....	23
Orange pests .....	23
Pineapple insects .....	26
Coffee insects .....	27
Bees .....	27
Miscellaneous notes .....	28
Report of the chemist .....	29
Introduction .....	29
Soils .....	29
Bat guanos .....	30
Fertilizers .....	31
Report of the coffee expert .....	33
Improvement of an old coffee grove .....	33
Experiments with new plantings .....	34
Report of the plant pathologist .....	35
Report of the assistant animal husbandman .....	37
Horses .....	37
Cattle .....	38
Sheep .....	39
Goats .....	39
Hogs .....	39
Notes on the soils of Porto Rico .....	40

## ILLUSTRATIONS.

---

	Page
PLATE I. Fig. 1.—Side of the Station Plant Houses, Fig. 2.—Silo, Grain Cutter, and Elevator .....	8
II. Fig. 1.—Sword Bean ( <i>Canavalia sp.</i> ) 5 months from seed- ing. Fig. 2.—Sword Bean growing between rows .....	16
III. Fig. 1.—A native Seedless Orange. Fig. 2. Breeding ex- periment with native Muskmelons. Hybrid in center .....	24
IV. Fig. 1.—Mealy Bug on Pineapple slips. Fig. 2.—Spreading Coffee to dry on Plaza .....	32
V. Fig. 1.— <i>Crotalaria retusa</i> , a native leguminous plant. Fig. 2.—Molds for constructing Cement Fence Pósts .....	40

# ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1908.

## SUMMARY OF INVESTIGATIONS.

By D. W. MAY, *Special Agent in Charge.*

### INTRODUCTION.

Continued progress may be reported in agricultural conditions in Porto Rico. This may be noted in the general growth in prosperity of the whole island and is further evidenced by the increase in exports, all of which are agricultural products. A constant increase may be noted in the value of exports from the year 1901 to the present. During 1901 the value of merchandise exported was \$8,549,093. During the year 1908 the value of the exports was \$30,601,639. This latter sum represents an increase over the exports of 1907 of \$3,637,022.

The total value of the exports does not tell the whole story. The home consumption of many articles produced has greatly increased. This is due to the fact that the general prosperity of the whole mass of the population has been bettered, thereby increasing its purchasing power. The exports of some articles have fallen off owing to local demand. In 1901 there were exported cattle to the value of \$457,983, while in 1908 the export of cattle was valued at only \$600.

The matter of greatest importance to the station during the fiscal year was the providing of additional funds by congress for carrying out work already inaugurated and permitting the study of other questions of no less value to the progress of agriculture and the benefit of the Island of Porto Rico. Second in importance was the appropriation made by the insular legislature of \$20,000 for the erection of a building for the exclusive use of the experiment station. Since its inception, the work of the station has been carried on in an old sugar mill that stood on the plantation and which is wholly inadequate to the growing needs of the station. The erection of the new building, to be of cement construction and to stand on an elevation near the building now used for that purpose, is under way. This building, while supplying a very urgent need of the experiment station, is also an indication of the appreciation of the work of the institution by the people of Porto Rico.

During the year a chemical laboratory was installed, equipped with a gas plant and water. This has been placed temporarily in the old sugar mill building until the new home for the use of the station shall be erected. A warehouse building has been constructed for the housing of fertilizers and machinery. This

has been built partly of brick, which were made upon the place. A dairy barn and silo have also been erected.

The work of the station during the year has been essentially along practical lines. Agriculture in the Tropics has not had the study that it has received in the Temperate Zone. Many methods that are followed in more advanced countries of the world are still the subject of experiment in the Torrid Zone. It is necessary not only to study the improvement of agricultural operations under entirely new conditions but to prove the wisdom of the application of certain well-known principles that obtain in temperate regions.

The greatest need in agriculture in the tropical regions of the earth is the improvement of the economic plants and animals, in other words, plant and animal breeding. The economic plants and domestic animals usually show, either no improvement, or else a positive degeneration. No other line of work promises such a reward for patient endeavor as the improvement of the different varieties of economic plants and animals. With a continuous growing season, plants are allowed to produce decreasing harvests from year to year through ratoon crops instead of being more frequently planted. Again, as seed time follows closely on harvest, economic plants are grown from bulbs or cuttings to a greater extent than in the Temperate Zone. This has a tendency to give decreased yields and to produce plants of lessened vitality. One of the principal lines of work, therefore, of this station is the propagation and dissemination of plants and animals of greater productivity.

Among the plants that are being improved by selection and breeding are the following: New varieties of sugar cane grown from seed, pineapples from seed; the cowpea for the purpose of producing a variety best adapted to the soil and climate of Porto Rico; improved strains of muskmelons, cucumbers, sweet corn, and other vegetables.

Of no less importance to Porto Rico is the introduction of economic plants of other countries. (Pl. I. fig. 1.) This line of work has been extended to a great degree during the past year, and some of the plants mentioned in former reports have fruited for the first time in the trial grounds. It has been necessary to lay out a new orchard to receive the varieties of citrus and other fruits that have been introduced. Twenty-four additional varieties of mangoes have been received and planted. One hundred more trees of the grafted Indian mango have been planted in the ground of the station, while a number have been sent out to different sections of the island for trial.

Special attention has been paid during the year to the introduction and propagation of forest trees. There is a considerable area of land in Porto Rico, lying between the fertile cane fields of the coast and the coffee groves of the interior, that yields a very small revenue to the owners. These hills and mountains have been denuded of their forest growth and because of heavy rains have become almost worthless. Experiments indicate that such areas can be reforested and that in this and no other way can they be brought to a state of productivity. Al-





FIG. 1.—ONE OF THE STATION PLANT HOUSES.



FIG. 2.—SILO, SILAGE CUTTER, AND ELEVATOR.



ready a number of hills of this description on the station farm are showing the results of planting. Among the more promising trees may be mentioned the Indian mango, the eucalyptus, and the mahogany. On low grounds of the station there have also been planted groves of *Castilloa* rubber, cacao (some twenty varieties), and cocoanuts.

During the year a trip was made by the special agent in charge to the Leeward and Windward islands and the Spanish Main, visiting the British and French stations and Venezuela. As some of these stations have been established for more than a quarter of a century, a great deal of benefit was derived from their personal inspection and a study of the results attained. The horticulturist also made a trip through Cuba and Florida for the purpose of studying the methods of growing citrus fruits and pineapples. As the pineapple industry has become a leading one in Porto Rico, it was especially necessary to make a personal study of the methods of handling old pineapple plantations to obtain continued favorable results.

It has been found advisable to take the experiment station to the plantations, and to best carry out this idea, cooperative experiments have been arranged in different sections with representative planters. These cooperative experiments are for the purpose of introducing new crops and studying methods for improving the soils both by fertilization and manipulation. These experiments are under the direction of a number of the station staff, but the expenses are borne by the planters. Many valuable results have been obtained not only for the plantation where they are carried out but also for the neighborhood. They form a focus where planters may meet with the members of the station staff to discuss the methods employed and the results obtained. Some results along these lines are very striking. In one series of experiments in the fertilizing of orange groves, it has been found that different elements of the fertilizer affect not only the shipping quality but the flavor of the fruit.

The growing appreciation of the Station and its work is shown by the largely increased correspondence and in the number of visitors during the year. Requests for personal inspection have been greater than it has been possible to supply. The extension of the Morrill Act to Porto Rico with the establishment of an agricultural college, which will be organized during the coming year, will render assistance to the station in putting its results before the people, and also in supplying trained agriculturists to meet the demands from progressive planters for skilled assistants.

The greatest need of the station at the present time is to secure and hold well-trained men in its service. When a vacancy occurs it usually takes a long time to fill it and much valuable work is stopped. Again, when good men are secured the service should be made so attractive that they would not leave it for any slight increase in salary or betterment of location.

The station is situated outside of Mayagüez, and it is somewhat difficult for the employees to go to and from the City to their work. Could funds be secured for the purpose, it would be



advisable to construct a building on the station grounds for the housing of such employees as cared to live there and where those living in the city could obtain luncheon at midday. Such a home would add greatly to the attractiveness of the service at the station. Occasionally experts from Washington visit the station for a greater or less time, looking into some special problems, and it would also be a great convenience if these investigators could secure comfortable temporary quarters. It would be to the advantage of the station to keep such men as long as possible and to give them every facility for carrying out their investigations.

#### SUGAR CANE.

The greatest export in value of Porto Rico at the present time is sugar. This has shown a continuous increase since the American occupation. In 1901 the value of sugar exported was \$4,715,611, in 1908 this amounted to \$18,690,504. The value of molasses exported has been fairly uniform for seven years, but showed a great decrease in the past year. The exports of molasses in 1901 were valued at \$595,902, and these figures varied very little from year to year up to 1908, when the amount fell to \$267,184. This is largely due to the manufacture of denatured alcohol, which is assuming some importance in Porto Rico. It is undoubtedly true that the abundant supply of low grade molasses furnishes one of the cheapest sources of denatured alcohol, and its consumption on the island is increasing rapidly. Some experiments made at the station show that it is by far the cheapest fuel available for cooking purposes. For many years Porto Rico has used charcoal in the kitchen and this has been largely responsible for the deforestation of the lands. Denatured alcohol is much cheaper than charcoal, and its use will prove an important factor in assisting to reforest many unproductive areas.

The increased production of sugar has been brought about by the planting of more lands and by increasing the productivity of those under cultivation. The extension of cane planting cannot be very much greater owing to the fact that available lands are already nearly all taken up. The possibilities of increasing the yield per acre are more promising. Porto Rico has long been famous for the richness in sugar of her canes. The continued cultivation of this crop for so many years indicates the inherent strength of the soil. By the application of the methods of scientific agriculture no doubt the former fertility of the lands may be restored and the fields brought to the front rank in the yield of sugar.

The results of experiments covering several years, which have been carried out in cane production at the station, have been incorporated in a bulletin soon to be issued. A few statements of the results may prove interesting here.

As regards climate there are two cane growing areas in Porto Rico, one is the dry section, extending along the entire southern coast, where irrigation must be practised to get the best results, and the other is the rainy section, on the north side and the eastern and western ends of the island. The interior of Porto Rico, while well watered, is so mountainous that the question



of transportation has precluded the growing of canes except in valleys here and there where there is enough land available to permit of the operation of small mills. One of the great needs of the dry section is more irrigation. Many of these fields are comparatively new and they need only an abundance of water to permit of the production of maximum crops. A number of irrigation plants are in operation, but they are inadequate to the needs of the lands available for cane production. Bonds have been issued by the insular government for diverting the Manatí and other rivers to the south side of the island for irrigation purposes. This water will be sold to the plantations and the resulting revenue used for retiring the bonds. This project will result in greatly increasing the yields of the lands on the south side and add to the total production of sugar. These lands need fertilizers less than others that have been cropped for a long series of years.

In some cases the soils in the dry sections are impregnated with alkali. From the results of analyses made of a number of such soils, the planters are advised to use gypsum to correct this alkalinity and thus bring the soils into proper culture. The indications are that at a small cost these lands may be reclaimed.

Most of the soils in the regions of heavy rainfall are of a heavy tenacious clay. While fertilizers can be profitably used on most of them, at the same time it is highly advisable to improve their physical texture. The usual method of draining such soils is by open ditches, which must be made and cleaned continually and at great expense. In most of these lands tile drainage could be very profitably adopted. The tiling of the low lands at the experiment station has proved very successful and may be classed as a permanent improvement, obviating the constant necessity of cleaning open ditches. Some planters are putting in tile ditches and the results indicate this method of drainage to be highly profitable.

A great many of the heavy soils also require liming, not only to correct the acidity but to improve their physical condition and bring about better tilth. In lands where there is a great deal of organic matter, this has proved very profitable, and has reduced the fertilizer bill by putting the soils in such condition that small amounts of manures are more effective than large amounts were formerly. In many instances liming has preceded fertilizing because the physical condition was such that the sugar cane could not profitably utilize the fertilizers that were added.

Comparatively Porto Rico has been long settled and the soils are very much worn, needing in nearly all cases the three elements, nitrogen, phosphorous, and potash. Of all these elements, however, nitrogen is the most important and its application governs the production to a great extent. As long as present prices of sugar continue the lands now devoted to cane will continue to be planted to that crop. This production of the crop on the same land year after year is against the best practices of agriculture and cane growers must study methods of overcoming the drawbacks in soils continually subjected to a lack of diversification.

There is no resting period of several months, as is the case in the North, but when one crop of cane is removed another immediately follows either from the old stubble or from immediate replanting. To add nitrogen to the soil, a series of experiments has been begun at the station in which certain legumes are grown between the rows of cane. These are planted soon after the canes are cut and the period covered extends from 60 days with cowpeas to the entire year with the sword bean. These crops not only add to the soil nitrogen, which is very much needed by the cane, but they improve the physical condition of the land and doubtless remove some of the toxicity of the soil produced by the old cane roots, should any such exist.

In experiments in distances of planting, the close planting as is usually followed in Porto Rico has proved the most profitable method. The wide planting such as has been advocated in Cuba of late not only gave decreased yields but added to the expense of cultivation, owing to the fact that the malojillo grass had more sunlight and space between the rows of cane in which to grow.

The experiment station is carrying on the work of breeding new varieties of cane by planting the little seeds in the arrow, and some very promising new varieties have been developed. For several years the best seedling canes developed by the British stations, cuttings of which have been kindly sent us from time to time, have been grown and distributed. Some of these canes both in the laboratory and in car lots sent to the mill have proved much richer in sucrose than the old varieties of cane commonly grown in Porto Rico. Some of these canes in the island have run over 20 per cent of sucrose in the juice, and it is expected that further work along this line will finally develop varieties of cane that will average over 20 per cent sucrose in field trials.

#### TOBACCO.

The second export in value is tobacco. While the export of leaf tobacco has shown a great increase from year to year it has not kept pace with the increase in manufactured tobacco in the form of cigars. This is probably owing to the abundance of skilled labor available; and the export of cigars will likely increase over that of the leaf tobacco. At the experiment station the heavy soils do not produce a high quality of cigar leaf but produce a most excellent Burley plug tobacco. The sections devoted to the production of cigar leaf are in the interior, notably from Caguas to Aibonito. There has been a steady increase in the amount produced and also an improvement in the quality. The production of wrappers grown under cheese cloth is in the hands of large companies. Filler tobaccos are produced not only by the companies but by a great many small planters who either sell their product cured or as cut from the field. There needs to be more scientific study made of the tobacco soils of Porto Rico for the purpose of mapping them and more especially to determine their fertilizer requirements. Owing to the distance and cost involved, the experiment station has not been able to carry out any experiments in the tobacco districts during the past year. The Porto Rican American Tobacco Company has established an



experiment station near Caguas and during the coming year this station will cooperate with them in several lines of work. During the past year different members of the station staff visited the tobacco sections advising the planters in regard to seed beds, fertilizers, and the proper fermentation of the crop. Some analyses have been made of typical soils in the tobacco growing sections.

#### COFFEE.

There has been some slight improvement in the coffee situation in the last three years. Prices continue low, and owing to the heavy production of coffee in Brazil the outlook for the future is not bright. There has been some increase in the production brought about largely by cleaning, cultivation, and pruning of the existing coffee trees. Very few new trees are being set, and the coffee planters are seeking new crops to which to turn their attention. Under a separate heading will be found the report of the coffee expert showing the progress of the work at the substation in the mountains. (See p. 33.) Endeavor is being made to promote better agricultural methods with Porto Rican coffee. In the meantime in order to obtain better prices, it would be advantageous for the United States Government, by reciprocity treaties, to secure for Porto Rico more favorable trade relations with countries that consume its coffee. A large part of the coffee is sold to Cuba and the rest to France, Spain, and other countries of southern Europe. The value of coffee depends upon its flavor, and while Porto Rican coffee is one of the highest of a certain type, it is a class that is relished in some foreign countries more than in the United States. The consumers in the States prefer a highly flavored aromatic coffee like the Java. In order to meet this demand the experiment station has introduced and is growing the best quality of Javas. Coffee growers are very much interested in this work, and during the past year a great many seeds were distributed among them for trial. This seems the best way to meet the market of the United States.

#### FIBERS.

It has been proved that certain sections of Porto Rico are well adapted to the production of a very fine quality of sea-island cotton. This industry, however, does not make much progress. There is a lack of planters skilled in the production of this crop. Moreover, it is a crop requiring strong land and unremitting attention. Cotton growers are not disposed to spend such amounts for fertilizers as are found desirable in growing this crop on the sea islands of the Carolinas or in Georgia. With the same skill and attention in growing the crop, the returns in certain sections of Porto Rico would fully equal those obtained in South Carolina or Florida. The exports of sea-island cotton during the past year were \$64,677, which is over double the amount of the previous year.

Several hundred pounds of the best sea-island cotton seed received from the United States Department of Agriculture have been distributed among the planters. This is a crop adapted to

small holdings and an industry to be followed by the small farmer, as it requires but small capital and the women and children of the household can be employed in its production. It is a new industry, however, in most sections and gains ground slowly. Its especial needs are that the growers practice improved methods of tillage, the use of manures, and measures against the cotton caterpillar. In growing sea-island cotton in the States very large amounts of fertilizer are found necessary and planters must come to a realization that such must be used here to get high yields and the best quality of fiber. The well-known means of combating the cotton caterpillar must also be followed. This pest is to be expected and the planter should be prepared to meet it when it first puts in its appearance, otherwise severe losses will occur. The well-tested means if used promptly will easily keep this pest in check, and for that reason it is not to be feared as the cotton boll weevil which threatens the cotton industry in the Southern States but which does not occur in Porto Rico.

Another fiber industry that should prove profitable over certain areas in Porto Rico is the growing of sisal. This plant, which has proved very profitable in Yucatán, grows well in various sections of Porto Rico and its production should prove a paying industry in the dry limestone districts of the south side. The insular government has, through the experiment station, purchased 100,000 plants for trial and is seeking to interest capital in taking up the industry in the island. Being a crop new to Porto Rico, it is difficult to interest planters in the business, especially as it requires considerable capital and it is necessary to wait three years for the first returns. During the year 75 acres were planted to sisal under the direction of the experiment station on some government land in an arid section of the island. These plants are starting to grow with every promise of success. There is a great deal of land now lying idle that is valuable for this crop, and it is the purpose to make of the present planting a commercial trial. Many acres of land now nonproductive can be planted at a very low cost, it being found necessary only to cut and burn the brush, leaving a mellow and fertile seed bed.

The importation of the palm from which the Panama hats are made has proved successful, and a number of plants have been distributed among the producers of this class of fiber. In order to permit the making of the higher grades of Panama hats it will be necessary to grow the plants. An important industry of hat making has been operating for several years, the raw material being imported from Colombia. That country, fearing a loss of her leading industry, has put an export duty on the raw material, thus causing the closing of the several factories located in Porto Rico.

#### FORAGE CROPS.

Porto Rico possesses two splendid grasses, malojillo or Para grass and Guinea grass. Experiments are being continued at the station with the object in view of obtaining leguminous crops for improving the soil and also providing forage for animals. Of these the cowpea is the most promising. A number of other



leguminous crops imported from various countries are under trial. (Pl. II. figs. 1 & 2.)

During the year the experiment station has erected a brick silo, the first on the island and perhaps the first in the Tropics. (Pl. I. fig. 2.) The object of this is to test the practicability of ensiling grass during the season when it is most plentiful for use in the dry season; also to test the practicability of ensiling the tops of the cane during the grinding season. This material is now largely wasted, but if it could be preserved it would make a very valuable feed that could be utilized when needed. The silo has been filled with the malojillo or Para grass with indications of success. The silage is rather light to pack well and the waste in the preliminary attempt has been greater than it should be. However, it is very probable that this can be overcome. The cane tops from the experimental plats will be ensiled during the coming grinding season.

### LIVE STOCK.

As breeding cattle, those of Porto Rico are famous throughout the West Indies as being of superior merit. The exportation of cattle for slaughter has entirely ceased because of the greater domestic consumption of meats and also the necessity of more work animals in the cane fields.

The exportation of other animals has also practically ceased, those that are produced being needed for local use. The increased importation of animals and animal products indicates that many more can be profitably produced for local consumption than at present. With some changes in farm practice, the animal products of Porto Rico can undoubtedly be very greatly increased. Besides grasses there are many waste products which can be utilized for feed, and the work at the experiment station indicates that animals in a climate such as this can be produced with a much less outlay of feed than in the colder countries of the North.

From importations made by the station the indications are that all classes of live stock, including poultry, may be brought to the island from the States with comparative safety. The greatest danger is in the importation of cattle. The great drawback to cattle is the tick. The native cattle are not bothered to any great extent as owing to their short hair the ticks cannot very well hide themselves and are readily picked off by black birds which follow the cattle about the fields. Imported cattle, especially those having long hair, are infested to a much greater extent with ticks. This insect, however, does not appear in such numbers as on cattle in the Southern States. Moreover, as far as observations go, no virulent case, of tick fever has been noted. With the importation of over 50 head of cattle for various parties through the experiment station no losses have occurred from this disease nor apparently have the cattle been ill from it or "off feed." Cases from other parts of the island have been reported as resembling tick fever, but if it occurs it certainly does not possess the virulence, that it does in the States.

American cattle brought to Porto Rico should have better care than the native stock. The Porto Rican cattle can be turned

out to live on very scanty pasture, but with the coarse grasses and hot sun imported cattle must have better treatment. If it is desired to import Northern cattle for improving the herds the breeder is advised under usual circumstances to bring bulls to cross with native stock. These bulls can be stall fed and under such conditions their importation is comparatively safe.

A number of pigs and poultry have been bred and sold to planters in various sections of the island during the year. No unusual difficulties have been found in raising the improved strains. Pigs have been sold at weaning time at \$10 per head and the demand has exceeded the supply. The same may be said regarding the introduction of poultry including turkeys, geese, ducks, and chickens. The foundation has been laid for a dairy herd and a dairy barn has been built.





FIG. 1.—SWORD BEAN (*CANAVALLIA* SP.) 5 MONTHS FROM SEEDING.



FIG. 2.—SWORD BEAN GROWING BETWEEN ROWS.





# REPORT OF THE HORTICULTURIST.

By M. J. IORNS.

## INTRODUCTION.

Fruits ranked fourth in value among the exports of Porto Rico in 1908, and this is destined to be the leading industry, the results already attained being but a fraction of what may be expected in the years to come. Shipments of oranges showed an increase in value from \$84,475 in 1901 to \$630,720 in 1908. As the cultivated groves come into bearing this amount will be greatly augmented from year to year. The increase in pineapple exports has been remarkable for an industry of such recent development. The exports for 1907 were valued at \$128,350 and for 1908 at \$270,982.

As the horticultural work of the station proceeds, the practical problems incidental to a new country are gradually solved, and the work becomes more and more technical, hence the annual report becomes a report of progress rather than a discussion of results obtained, while bulletins or circulars are issued giving the results in detail. During the past year a bulletin on pineapples has been prepared by the writer and his predecessor, Mr. H. C. Henricksen. A circular on the picking and packing of citrus fruits with packing diagrams was also prepared.

In noting the progress of horticulture in Porto Rico, attention must again be called to the great need of trained help in the citrus groves. Many groves are coming into bearing and the available help for the proper handling of the fruit is very inadequate. It is evident that the packing houses must be equipped with all the labor-saving machinery possible. Even with this there will be much loss due to poor handling of fruit until more help can be trained for the work.

A horticultural society has been organized and the work of establishing standards for grading and packing begun and provision made for inspection. Much preliminary work has been done, and it is hoped that by next year the recommendations of the society will be put into practice. The society has also taken steps toward the inspection and control of imported plants, so in that line also results may be expected. During the year a paper called "The Porto Rico Horticultural News" has been established under the auspices of the society. The horticultural department, of the station, by means of this paper, is able to reach the growers with seasonable suggestions gathered from results of work at this and other stations. This is an extremely valuable aid in the advancement of the horticultural work in the island.

### INSPECTION TRIPS.

In order to gather data on pineapple and citrus fruit growing the horticulturist was sent by the station on an extended trip to Cuba and Florida. On the way, about a week was spent at various points along the south and west shores of Santo Domingo and Haiti, and at the various ports short trips were made into the surrounding country. Several vegetables and fruits of considerable promise were collected and are now being tried on the station grounds.

In Cuba most of the larger fruit growing sections were visited and considerable data gathered. Special attention was paid to the pineapple sections in Cuba where definite systems of culture and handling of the fruit have been worked out.

The chief point investigated in Florida was the method of handling the fruit. A large number of the more modern and complete packing houses were visited, and many valuable suggestions were received and data collected covering every phase of the fruit growing industry.

Many trips have been taken to the various parts of the island for purposes of demonstration and advice. More of this valuable work should be done as the work of the department permits. This is especially necessary because of the large number of newcomers who are starting fruit plantations.

### COOPERATIVE WORK.

In the cooperative work with citrus fruit growers some very interesting data are being obtained. The results cannot be definitely reported until much more work has been done, yet they may be stated tentatively. (1). As indicated in last year's report, the effect of the complete fertilizers as compared with the incomplete is very marked. The dried blood as a source of nitrogen and potassium chlorid as a source of potash gave the greatest amount of vegetative growth. (2). In the bearing groves the legumes seem to be able to supply the major part of the nitrogen necessary, especially if the cover crop is plowed under. (3). The source of the different food elements and their relative proportions materially affect the quality of the fruit. The organic fertilizers gave a coarser fiber and skin, while the unbalanced combinations gave poorly flavored and insipid fruits. (4). The amounts of fertilizer and time of fertilizing affected the time of fruiting.

Such are the chief points indicated by the work thus far. There are a number of other questions such as the effect of the fertilizers on coloring, flavor, juiciness, and other qualities, that are yet too indefinite to be stated. All this makes the subject of fertilizing one of the most vital problems the grower has to solve. The excellent results being obtained from the cooperative experiments have led to the undertaking of a number of other fertilizer experiments both in cooperation with planters and in the station orchards.

### THE ORCHARDS.

The work of experimenting with fertilizers, cover crops, and



culture in the orchards has been enlarged to considerable extent during the past year.

In order to have true standards for comparison, a new citrus orchard was planted with the more general varieties of the various citrus fruits. These trees were guaranteed to be true to name by one of the most reliable firms in Florida. This orchard will also be used to test the comparative value of stocks, as part of it is budded on the sour orange, part on the rough lemon, and part on the *Citrus trifoliata*, native seedlings, etc. (Pl. III. fig. 1.)

Pruning and cover crops are beginning to yield results and these are being given to the planters as fast as determined. Already the growing of cover crops has become quite a general practice and the station is pushing the work in every possible way. Systems of alternating cover crops and clean cultivation to check the washing of the soil, to keep the fruit clean, and to increase the soil fertility, are being worked out both on the station grounds and in cooperation with the various planters.

New plantings have been made of avocados, cacao, rubber, and guavas. These are all doing well and afford much more material for experimentation along needed lines.

In the orchard of miscellaneous and introduced fruits, the *Averrhoa carambola*, *Lucuma rivicoa angustifolia*, several of the new *Anonas*, *Triphasia monophylla*, *Myrtus tomentosos*, and *Spondias axillaris* all produced some fruit during the year. Some of these are very promising and will be propagated for distribution.

The number of improved mangoes has been increased by some twenty new varieties from different parts of the world. From those already in the orchard, over two hundred inarches have been made. Most of these have been used in making permanent wind-breaks about the citrus groves, but a few have been distributed to different parts of the island for trial. Several planters have tried transplanting native mango trees from one to four and even more inches in diameter. When this was done in the rainy season with a ball of earth and the tops were cut back severely, the loss was very small, while the gain in time was several years. Later it is hoped to find some way of working these trees over to commercially valuable varieties.

During the year, experimentation has been continued with the various forms of propagation, but a real commercial method aside from that of inarching still remains to be discovered. This work is of such importance that it will be continued.

While aside from strictly horticultural work, its importance has led the department to do considerable work with the eucalypts. Some thirty species are now on trial and a forest plat has been started for the purpose of studying their behavior. Considerable difficulty was experienced with the seedlings, and in connection with the pathologist, a series of experiments were undertaken to test methods for handling the plants from seed to setting out in the plat, and the troubles have been largely overcome. Much difference is being shown by the various species as to the hardness and rate of growth of the seedlings. To find some quick growing,

valuable tree for barren hilltops and otherwise waste lands is a very important work.

### THE GARDEN.

Following the lines indicated in the last annual report, considerable work has been done in the garden and much data collected.

Many additional points have been brought out regarding the influence of seasons. One of the most peculiar of these is the effect on roselle. When planted from January to May, the plants began to bear very young, in some cases when not more than a foot high. If the fruit was kept gathered before maturing, successive crops were formed on new growth until June or July. Fruit bearing then ceased until the latter part of October, when the main crop was borne, after which the plants usually died. A few plants were induced by heavy fertilization and cultivation to bear one more full crop early in December. If the seed was planted from May to August, no fruit was borne until the main crop was produced in October and November. The result of seeds planted from August to January remains to be determined. As roselle promises to be a valuable crop, more work will be done to further substantiate the above results.

Corn is another crop that shows apparently erratic seasonal variations, which will be made a subject of further study.

The grapes have made exceptional growth and some results have already been determined in the pruning experiments. By two heavy prunings, one in spring and the other in early fall, together with frequent bud pinching, three varieties have been forced into bearing. Other varieties have not been benefited and in some cases the effect seems to be negative. This indicates that much attention must be given to this phase of grape culture. Many cuttings have been distributed by the station and many plants have been imported by various interested parties. It is hoped that in a few years grape culture will be an assured industry.

Work has been continued with the acclimatizing, selecting, and breeding of various vegetables.

It is found that the grafting of the eggplant is not only practical but advisable, especially for home use. The best stock to be used is that of the *Berengena cimarrona*. In Jamaica they use the "susumber," but it has not thus far proved very successful in Porto Rico. The *Berengena cimarrona* is found in almost every part of the island and seeds can be readily obtained.

The commercial plantings of muskmelons proved very successful, and much larger plantings are now being prepared for spring shipments.

Chayotes have proved so successful in culinary lines that plantings have been made to test their market value in the States.

In the sandy soils of the north shore and of some portions of the south shore, onions have proved a very profitable crop and the acreage will, no doubt, be increased. The Spanish type is the onion most planted.



## PINEAPPLES.

A bulletin on pineapples has been prepared giving the results of the experiments and observations thus far made. New work is under way to further substantiate the less well established conclusions and to clear up some of the points raised by the past work.

Many seedlings are being raised and a number of promising new varieties are being further tested. Six new varieties from Florida have been received and are doing well. Of these two give special promise and will be propagated for trial distribution as fast as possible, but several years must elapse before a large quantity of plants is obtained.

Two new and interesting points are being brought out in the pineapple plantations. The first is that the Red Spanish does not adapt itself well to the heavy soils, while on the other hand the Cabezona seems to prefer such soils, providing the drainage is good. The second point is that some of the sandy soils are too fine grained for good drainage and hence are not suitable for pines.

The effects of different fertilizers on the quality of the fruit, time of fruiting, and the exact fertilizer requirements of the different soil types are being further investigated. The work of breeding a variety of spineless pines by selection is giving some promising results which warrant a continuation of the experiments. In new plantings it has been found advisable to grade the slips according to size and vigor into at least three grades and thus secure more uniformity in the maturing of the fruit.

## PLANT INTRODUCTION AND PLANT BREEDING.

Among the plants experimented with during the past year the following have given the best results:

A strain of cucumbers of the White Spine type has been developed that is much more resistant to disease than the ordinary form and bears heavy crops of extra fine fruit. It is not uncommon to find fruits weighing two pounds and more and these have retained their firmness and color for three and four weeks. Seeds of these have been sent to various parties for trial, and the reports thus far received indicate that the strain will prove valuable.

A strain of peanuts has been developed by selection that has an extra fine, large, sweet nut, and in the trial plantings, has yielded at the rate of over 90 bushels to the acre. A few seeds of this strain will soon be ready for distribution and it is hoped that it may become a commercial crop. There is a good home market and besides its value as a nut the plant is a fine soil renovator. It should make a valuable addition to the list of cover crops especially for sandy soils.

Three strains of cowpeas have been developed and samples sent out for trial. One of these bids fair to become a very excellent addition to the already large number of varieties. It differs from the general varieties in having a pod that is of a dark purplish color when ripe. It has made good growth and matured

good crops of seed when all the other varieties tried nearly failed. Besides these three strains, the station is acclimatizing several varieties of cowpeas and sword beans brought by the members of the station staff from Venezuela and some of the islands of the West Indies. Some of these promise to be of special merit.

The strain of "melón de China" mentioned in the last report, has been further developed by crossbreeding with the Rockyford. The resulting type has been propagated and many packages of the seed distributed for testing. The results thus far reported are very favorable. A quite striking result has been obtained by crossing the "melón de China" with the large native form. (Pl. III. fig. 2.)

An interesting point in plant breeding for disease resistance was discovered in this work. A large number of Blinn's best resistant strains of muskmelon were obtained through the kindness of the originator. Trial plantings were made of these and almost without exception the results were negative. In no case did the plants prove more resistant than ordinary ones. Furthermore, native resistant types have in two instances failed almost entirely. As indicated in the last report, there seem to be periodic waves of intense disease ravages and at such times even the strongest plants succumb. Work is being continued along certain lines to determine, if possible, the factors and causes of these periods so that they may be guarded against.

One variety of sweet potato has been found of sufficient merit to be distributed and another crop is almost ready for distribution. Only a few reports of these have been received to date.

Large numbers of trees of Barbados cherry (*Malpighia glabra*), Otaheite gooseberry (*Phyllanthus disticha*), Surinam cherry (*Eugenia mitchellii*), Amatangula (*Carissa arduina*), and Loquat (*Eriobotrya japonica*) are being propagated and distributed as valuable additions to the household orchards. A number of special types of guavas have also been distributed.

It has been proved that root cuttings of the breadfruit can be made, and also that new plants may be obtained with more certainty by a modified form of root cutting. This is done by clearing away the soil and exposing the larger roots for several feet, after which they are severed about two feet from the tree and the ends left exposed. In a short time new plants will start from each cut end. When these are well rooted they may be cut free and transplanted. By this means a number of new plants have been obtained from the seedless breadfruit.

## REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

Many trips have been made into the fruit, sugar-cane, and coffee districts of the island to investigate various crops which were infested by insects. Those infesting the orange and pineapple have occupied most attention, and a number of new lines of work have been taken up, among them, the fumigation of pineapple slips for the mealy bug, the destruction of ants in pineapples and oranges, also testing the various oil emulsions used by planters, to determine at what stages the purple and white scales were killed by the various strengths and the number of sprayings necessary.

Miscible oils are being tested, many of the formulas proving far superior to the kerosene and crude oil emulsions. A few of the planters are now purchasing ingredients and making these emulsions. From the results in the experimental and demonstration work in various groves, it is recommended that the miscible oils be given a thorough trial in combating the various scales. These oils have been used on the white scale with exceptionally good results. At present the ingredients for miscible oils have to be obtained in the States, but it is expected that soon some of the firms on the island will carry a complete stock.

### ORANGE PEST.

The hemispherical scale (*Saissetia hemisphaerica*) can be found only in limited numbers in the groves at present and is not causing any trouble. In the protected groves it is being held in check by fungi.

The purple scale (*Lepidosaphes beckii*) is causing a great deal of trouble in all plantations not protected from the wind and where systematic spraying is not practised. The life history of this scale has been worked out. It takes the female scale from 56 to 65 days to develop and produce her young. The male scale reaches maturity in about 35 to 40 days. From observations made throughout the year it was found that the young appear at no definite period but at all seasons. On account of this continual appearance of young, no definite time for spraying can be followed as with other insects.

*Life history.*—The eggs are very small and pearly white, and from 30 to 75 in number. The laying continues over a period of 8 to 11 days, the first eggs hatching before the last ones are laid. Some eggs kept in the laboratory did not hatch until the 18th day, while others under the same conditions hatched in 8 days.



The young usually crawl from 12 to 14 hours, after which they insert their beaks into the epidermis of the leaves, branches, trunks, and fruit, and at once develop a covering of white waxy threads. Under this coat or covering they remain for about two weeks, when they form a second covering. At the end of three weeks the male scale can be distinguished from the female. The adult male appears in about five weeks and can be seen with the aid of a glass crawling over the leaves and branches. At this period the females are not fully developed, it requiring seven to nine weeks. At the end of this time they are found with eggs. Individual cases were observed where females developed with full sets of eggs in seven weeks and the eggs commenced to hatch in eight weeks, thus making the life history nine weeks. Other insects under observation at the same time and raised under the same conditions took ten weeks.

The male scale is much smaller than the female, being about 1.5 mm. long and 0.5 mm. wide. Color, reddish-brown to dark-purple.

Adult female scale, dark-purple or reddish-brown; size, 2.5 mm. to 3 mm. long; breadth varying from 1 mm. to 1.5 mm. The female scale looks like a minute oyster shell and for this reason is often called the "oyster shell scale." It should not, however, be confused with the oyster shell scale of the North, as they are quite distinct species.

The purple scale has no definite seasons for producing its young. Crawling young have been found at all seasons of the year here at the station and also in various groves over the island. On account of this irregular appearance it is very difficult to accomplish thorough spraying. The adult scales and eggs are not killed by any of the emulsions heretofore used by the planters. It is now recommended to those who are using kerosene and crude oil emulsions to repeat their spraying in about twenty-one days, thus leaving ample time for the females which escaped the first spraying to deposit their eggs and for these eggs to hatch so that the larvae may be killed by the second application. This method of spraying has been used by a number of planters with very satisfactory results.

The red scale (*Chrysomphalus ficus*) has been sent to the station for determination a number of times during the past year. This insect is much harder to kill than the purple scale, but the young seem to come forth at a definite period. The life history of this insect has been worked out and it was found that the female develops in about the same time as the female of the purple scale. The male scale develops in about 35 days and crawling young generally appear in from 52 to 58 days. The complete life history of this insect will be found in a bulletin to be issued soon.

White scale (*Chionaspis citri*). During the past season this insect appeared in a great number of the older groves, and at the present time is causing the planters a good deal of trouble. The life history of this insect has been worked out, and it requires about the same time to complete its cycle as the purple scale. It does not yield so readily to the sprays as does the purple scale. The first infestation is found on the trunks and large branches.



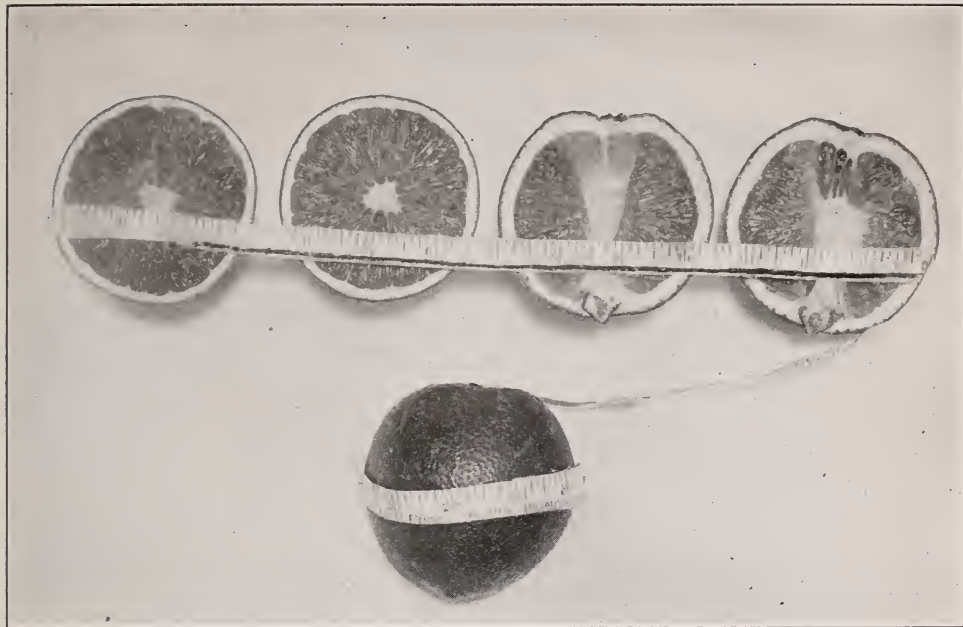


FIG. 1.—A NATIVE SEEDLESS ORANGE

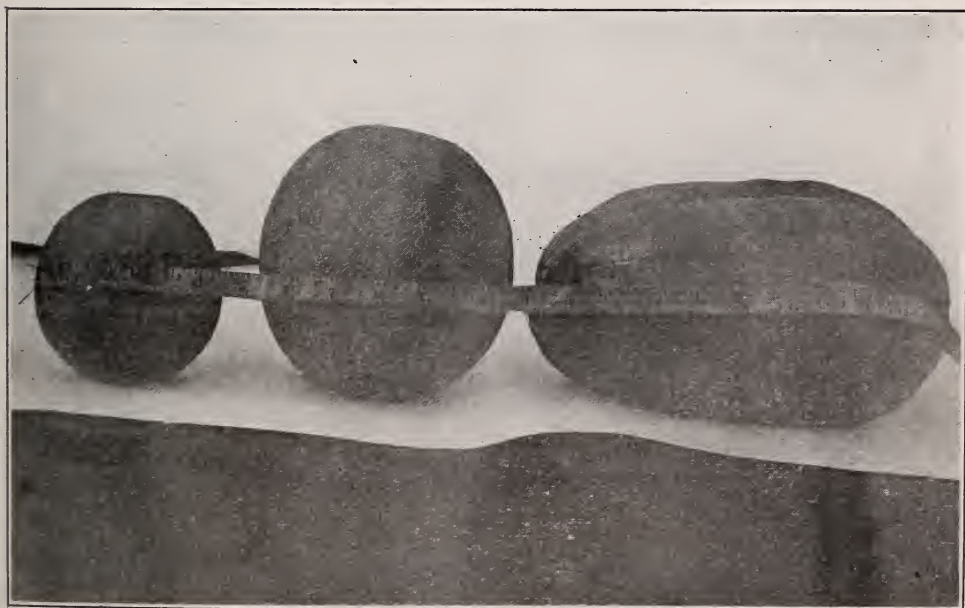


FIG. 2.—BREEDING EXPERIMENT WITH NATIVE MUSKMELONS.  
HYBRID IN CENTER.



The young spread more slowly than the purple scale, gradually working up into the tops of the trees. This insect is not preyed upon by the same or as many fungi as work upon the purple scale. There is one fungus, however, which has been found preying upon the white scale, but it operates very slowly.

One spraying with kerosene emulsion, 1 to 5, does not kill the mature female scales with eggs, but the young with their first and second covering are destroyed. The same can be said of crude petroleum emulsions, 1 to 18. It is, therefore, recommended that a second application be made at the end of about three weeks. If there is fruit on the trees a different formula should be used. A kerosene emulsion, 1 to 7 or 8, or crude oil emulsion, 1 part of stock solution to 20 parts of water, should be used, three applications being made at intervals of three weeks. It is also advised that this spraying should be carried on at a time when there is little fruit on the trees, preferably about the time of blossoming. One spray should be applied one week before the blossoms open, the next two sprayings at intervals of three weeks.

It has been the practice among the planters to defer spraying until the trees are in a bad condition.

This is not a wise practice, since many of the trees are coming into bearing and the fruit will surely be covered with scale and will have to be washed. It is well known that washed fruit is not equal to clean, unwashed fruit. Some trees have fruit on them all the year, but it seems best to do systematic spraying at the time when the blossoms set, so that the coming crop will have a clean start. If the scale appears later there are a number of sprays that may be applied to check the scale and not injure the fruit.

The rufous scale (*Pseudaonidia articulatas*,) was first sent to the station during the past year. Since that time it has been found in some of the groves, causing a little trouble. It appears on the under side of the leaves and also on the fruit, but it is very seldom found on the branches. This insect can be held in check by using the same remedies as recommended for the purple scale.

Orange leaf-weevil, (*Diaprepes spengleri*.) This insect was described in the annual report for 1907 as appearing during the latter part of May, but it has since been observed in great numbers during November, there being two broods during the year. A few of these insects can be found at all seasons of the year. The orange is not its only food plant; it has been found feeding on the guava, mango, and the blossoms of the rose.

The "vaquita," a small green beetle, has been causing a good deal of trouble in the orange groves on the northern coast. It is not found on the west coast. It feeds upon the young, tender leaves and also has been reported by a number of planters as scarring the young fruit. Arsenate of lead is being used to combat it, at the rate of 3 to 4 pounds to 50 gallons of water, and the planters are reporting that their fruit is practically free from scars.

"Caculos" and May beetles are causing a great deal of



trouble in the young groves, and one or two cases have been reported where young trees have been defoliated. The caculo is the larva of the May beetle and works on the roots of the tree while the beetle works on the foliage. In the older groves the beetles have much more to feed upon and the damage is not so marked. Many of the planters are hand picking the insects, while others are spraying with arsenate of lead. Where the trees are small, hand picking seems to be more economical than spraying and better results are obtained. Arsenate of lead may be added to Bordeaux mixture or it may be used with kerosene emulsion.

#### PINEAPPLE INSECTS.

The mealy bug has been found in all the pineapple sections of the island, (Pl. IV. fig. 1) but in the district of Carolina they are causing very little trouble.

During the past season Circular No. 7 was issued on the ants and mealy bugs in pines, and the emulsion recommended has been used by many planters with good results.

Previous to the planting season the slips and suckers of the old plants were found badly infested with the mealy bug. A number of tests were made with kerosene emulsion as a dip, but this did not prove wholly satisfactory as sometimes the mealy bugs would survive the treatment.

Carbon bisulphid was tried for fumigating, but this proved very unsatisfactory. The gas, being heavier than air, sinks to the bottom of the box and the insects in the upper part are not killed. On examining the fumigated plants, it was found that a very high per cent were injured, especially the Cabezonas. The Red Spanish slips and suckers were not hurt, except those which were fumigated for an extended period.

Hydrocyanic acid gas was used for the fumigation of slips and suckers on a small scale with very satisfactory results. On account of the scarcity of plants the tests made did not seem sufficient to thoroughly justify the treatment, so the experiment was continued in cooperation with a planter. Ten thousand slips were offered for the tests and were run through the fumigating box with various strengths of gas. Some were planted immediately and others after having been left in the shade for a while. After these had been in the ground three weeks 40,000 more plants were fumigated. The growth of the slips seemed to be retarded a little, especially in the first 10,000 but this was not wholly the effect of the fumigation, as the slips were planted in a very dry period. The group of 40,000 were planted during the wet season and started up much more quickly. Of the 50,000 plants fumigated a very small percentage was lost and hardly any were seriously injured. The mealy bugs in all stages were killed with one ounce of potassium cyanid for every 100 cubic feet.

A number of plants were taken from the box and immediately placed in the sun light; the leaves at once became yellowish white and in a few weeks dried up. The hearts of these plants and lower parts of the leaves were not injured and in a few weeks

were sending out roots, although they were not planted. This discoloration will not appear if the plants are left in the shade at least 24 hours after fumigation.

It is not advisable to fumigate wet plants, as the moisture which collects between the leaves forms an envelop that prevents the gas from passing down to where the insects are working.

For this fumigation a box containing 75 cubic feet was used and proved to be a very convenient size. Plants for the fumigation tests were gathered in sacks in the fields and brought to the box and fumigated without being emptied. After the fumigation the plants were removed from the sacks, sorted, and placed in bins according to size. The same results were obtained with plants which were first stripped and then fumigated. Where a great many thousand are to be fumigated it is more convenient to run them through before stripping, as the plants can be sorted later as needed, while if they are stripped first they must be planted very soon after the fumigation or they will spoil. It is not always convenient to plant at once, so it is recommended to fumigate, size, and strip, just before planting.

#### COFFEE INSECTS.

A coffee weevil has been found the past season in a number of the plantations around Ponce, and in some districts the planters complained that it did a great deal of damage. Some of the trees attacked were defoliated but soon put out new leaves and shortly appeared as if they had recovered. A study of this insect will be made next season.

The coffee stem borer was sent to the station for identification. At present it is not causing any serious trouble. Some damage is reported in one or two localities. This borer has other host plants, among them are the orange, citron, rose apple, and sweet almond. To destroy the insects run a flexible wire in the holes.

#### B E E S.

During July, 1908, the station purchased five nuclei of Italian bees in the States. They arrived in very good condition and were at once transferred to 10 frame hives. From time to time additional frames were added to the hives and by the first of October the bees began storing honey. Honey boards were put on with supers and by December 13 they were full. Thus in five months each nucleus had developed sufficient bees to raise brood and to develop 17 frames of comb, 10 of which were filled with honey.

The honey extracted has been of two grades; that collected from the general bloom of flowers has been classed as amber, and that which comes from the guamá, white. This tree is used extensively in coffee plantations for shade, and honey from it is said to compare very favorably with basswood or linden honey. It is a heavy honey plant and blooms three or four times during the year. Other plants or trees which produce heavy bloom or honey flows are the coffee, having from three to five short blossomings; the mango, one blossoming; the orange and grape-



fruit, generally two blooms; and the royal palm and cocoanut, several blooms.

The bees have not gathered honeydew up to the present time and it does not seem probable that they will as long as there are plenty of flowers. If at any time they should collect it in large quantities, it would be better to feed it back to them and let them make wax.

Most of the bee keepers are located in the interior, although there are a few apiaries along the coast in the lower foothills. The interior part of the island is the best locality, as the blossoming is more abundant. Any part of the island, however, is adapted to bee raising, except the south coast, where it is very dry and where at certain times of the year it would be necessary to feed the bees.

In the coffee sections where bees are kept it is said that the coffee is always much heavier than in sections where the pollenization is carried on by the wind. This has been noted especially in seasons of continual rainfall at time of blossoming. During heavy rains the pollen cannot be blown from blossom to blossom, which results in scanty setting of fruit. Under such conditions bees are very valuable, as they carry pollen whether the weather is wet or dry.

In Brazil it is reported that each coffee plantation has its bees and when the place is sold they are considered a fixed part of the property.

Another industry which seems especially adapted to Porto Rico is the raising of early queens for the Northern market. Queens can be raised here at any time of the year as we have no season when the bees do not work.

#### MISCELLANEOUS NOTES.

The guavas have been attacked during the past season by the mealy bug. A number of sprays were applied and it was found that kerosene emulsion, 1 part of stock solution to 6 or 7 of water, was very effective. These insects probably make the punctures on the young fruit through which the fungus enters that produces the mummy disease.

Great numbers of thrips have been observed on the underside of mango leaves. Their punctures probably allow the entrance of spores which produce anthracnose.

The following formula has proved very effective for destroying ants' nests: 1 pint of crude carbolic acid (100 per cent crude),  $\frac{1}{2}$  pound of whale oil or common laundry soap, and 1 quart of water.

Dissolve the soap in one quart of boiling water and add the carbolic acid and sufficient water to make a stock emulsion of two quarts. Use one pint of stock to 6 gallons of water. One spraying of ant hills is not sufficient, as many of the ants are away in the field at the time of the first spraying. These, upon finding their home destroyed, build a new nest close to the destroyed old one. A second spraying should be applied the next day when the ants are preparing their new home.

# RÉPORT OF THE CHEMIST.

By P. L. GILE.

## INTRODUCTION.

The chemical work the past year has been somewhat miscellaneous in character, as an attempt has been made to accomplish something besides the routine analytical work. The first part of the year was spent in fitting up the laboratory, installing a gas machine and other apparatus. Along with the analysis of the samples sent to the station and the chemical work done for the other departments, some research has been conducted on the catalase content of soils. The results of this investigation will be published separately.

The analytical work can be summarized as follows :

- 23 complete analyses of soils.
- 20 analyses of soils for one or two constituents only.
- 4    "    " limestones.
- 16   "    " bat guanos.
- 6    "    " commercial fertilizers.
- 2    "    " fertilizing materials.
- 2    "    " ores.
- 1 mineral analysis of water.
- 19 analyses of citrus fruits for fiber and acidity.
- 21    "    " sugar canes.

## SOILS.

A complete chemical analysis has been made of 23 soil samples, and an equal number have been examined in a general way for acidity, lack of humus, etc. While the idea has been to secure a knowledge of the chemical composition of the various soil types of the island, it has not been possible nor advisable to make a complete analysis of all the soil samples sent to the station inasmuch as the chemical analysis of a soil is a long and expensive piece of work. Such analyses have only been made when the soils have presented unusual features.

Many of the soils which have been studied, particularly the heavy clay cane soils, have proved to be acid. For such soils liming has been recommended, with the idea of neutralizing the acidity and at the same time of improving the physical condition. A plat experiment was started at the station to observe the effect of liming a soil of this character. Unfortunately the cane was blown down by a high wind before it reached maturity, so that no quantitative data could be obtained. The beneficial effect of liming, however, was quite apparent.

Several samples of very unproductive soils were received from the vicinity of Ponce and Santa Rita. On analysis they

were found to contain an abundance of humus and plant food, but to have a strong alkaline reaction. In this case a heavy application of gypsum was recommended, as Hilgard has found this beneficial in treating similar soils of California. The beneficial action of gypsum lies in the fact that it reacts with the alkaline carbonates of the soil, changing them into the less injurious sulphates. The results of this treatment will not be known until next year. Such alkaline soils occur only in spots and to no great extent on the island.

Field experiments have been made on the behavior of lime and gypsum on Porto Rican soils and also on the stimulating effect of carbon bisulphid on sugar cane and pineapples. The results of the experiment on the stimulation of pineapples by treatment of the soil with bisulphid have been such as to warrant the repetition of the experiments on a larger scale the coming year.

#### BAT GUANOS.

Bat guanos are found in many caves on the island and often in considerable quantity. The character on of these deposits varies greatly, depending on the age and amount of leaching that they have been subjected to. Some samples that have been examined have suffered practically no decomposition, while others are so completely decomposed that they contain almost no trace of organic matter. These latter appear like a reasonably pure limestone or sometimes like an ordinary ferruginous soil, the only evidence of the former accumulation of organic matter being the high phosphoric acid content.

Below are given the analyses of sixteen samples of guanos received from various parts of the island.

#### ANALYSES OF PORTO RICAN BAT GUANOS.

Sample No.	Moisture Per cent	Volatile Matter Per cent	Ash Per cent	Nitrogen Per cent	Phosphoric Acid Per cent	Potash Per cent
27	8.66	16.96	74.38	.88	12.13	.29
28	14.33	53.61	32.06	5.58	6.90	.24
29	7.80	37.32	54.88	.51	.75	.09
17	7.67	36.79	55.54	1.99	8.49	.55
36	4.35	10.63	85.02	.09	2.88	.23
40	2.86	24.34	72.80	.09	8.84	.79
41	5.85	26.77	67.38	1.92	14.11	1.90
42	13.80	14.52	71.68	.76	12.44	.41
43	6.66	10.48	82.86	.12	16.65	.71
44	8.63	12.72	78.65	.17	21.42	1.47
60	8.34	15.68	75.98	.20	17.84	....
61	7.84	27.22	64.94	.30	3.33	.05
62	2.72	27.34	69.94	.10	15.61	....
64	16.57	10.29	73.14	1.12	2.85	.98
65	17.43	71.98	10.59	9.27	4.31	.77
72	3.77	27.65	68.58	.04	2.63	....



The volatile matter in the above table is not to be taken as a true indication of the amount of organic matter contained in the guano since in many cases the volatile matter consists largely of  $C O_2$  evolved from the carbonates present.

Only two of the samples, Nos. 28 and 65, contain appreciable amounts of nitrogen, and in these two cases the nitrogen is largely present in an unavailable form. From a microscopical examination it is evident that the samples are composed of fragments of insects that have suffered no decomposition. The chief chemical constituent of these fragments is chitin, a substance containing about 7 per cent of nitrogen. As chitin is exceedingly resistant to decay, the nitrogen that it contains must be regarded as unavailable. Experiments at the University of Tokyo have shown guanos whose nitrogen is all present in the form of chitin to be practically worthless.

Sample No. 65, however, contains beside the nitrogen present in chitin at least 4 per cent of nitrogen in another form, probably in urea and uric acid, which is readily available.

It can be seen that none of the samples examined contain much potash, many of them being but little richer in this element than the ordinary soil. In fact, it is very rarely that cave deposits of this kind contain as much as 2 per cent potash.

From the guanos that have been studied thus far it appears that most of them have little value as nitrogenous or potash fertilizers, but that they do contain sufficient phosphoric acid to make them valuable as phosphatic fertilizers.

The exact value of the phosphoric acid contained in the cave deposits as compared with other forms of phosphoric acid is not known. In most cases it is probably much less than that of the commercial forms. An attempt will be made to ascertain this the coming year.

Some of the cave deposits contain considerable lime which gives them an added value, particularly for acid soils. There are also many cave deposits with a considerable iron content. These are less valuable than those containing lime, since the phosphoric acid in this case is largely present in the insoluble form of ferric phosphate.

#### FERTILIZERS.

Since there is no law in force on the island providing for the inspection and certification of commercial fertilizers, very few samples have been analyzed this year. But from the few analyses that have been made and from the reports of the planters, who are using commercial fertilizers quite extensively, it is evident that there is a crying need for such a law protecting the buyer.

Cyanamid has been tested for deterioration on storage under the conditions existing in Porto Rico. This is a high grade nitrogen fertilizer formed from atmospheric nitrogen, coal, and limestone.

A ton of cyanamid was received at the station the first of January and on May 1, two samples of it were taken, one representative of all in the bin and one from the superficial layer only.

These samples were not analyzed until August 8. As the sample jars were not absolutely air tight there was probably some loss of nitrogen during the three months pending analysis, but this loss could not have been so great as the cyanamid would have suffered under ordinary conditions of storage. Analysis of the sample representative of the whole lot gave the nitrogen content as only 13.05 per cent instead of the usual 19 per cent or more. The sample of the superficial layer ran lower still, yielding only 9.48 per cent nitrogen.

The cyanamid stored in the bin was again sampled on December 10. As before a sample was taken of the superficial layer and one representing the whole amount. The sample of the whole contained 10.89 per cent nitrogen and that of the superficial layer only 9.44 per cent.

It is very evident that cyanamid deteriorates rapidly in this climate where the temperature and humidity are uniformly high. It is probable that the cyanamid undergoes a decomposition during storage similar to that which is supposed to take place more rapidly in the soil. At all events the final product of the decomposition and the form in which the nitrogen escapes is ammonia.

The evolution of ammonia takes place to such an extent that it can readily be smelled after a portion of cyanamid has been confined for a time; and moist litmus is quickly turned blue.





FIG. 1.—MEALY BUG ON PINEAPPLE SLIPS.

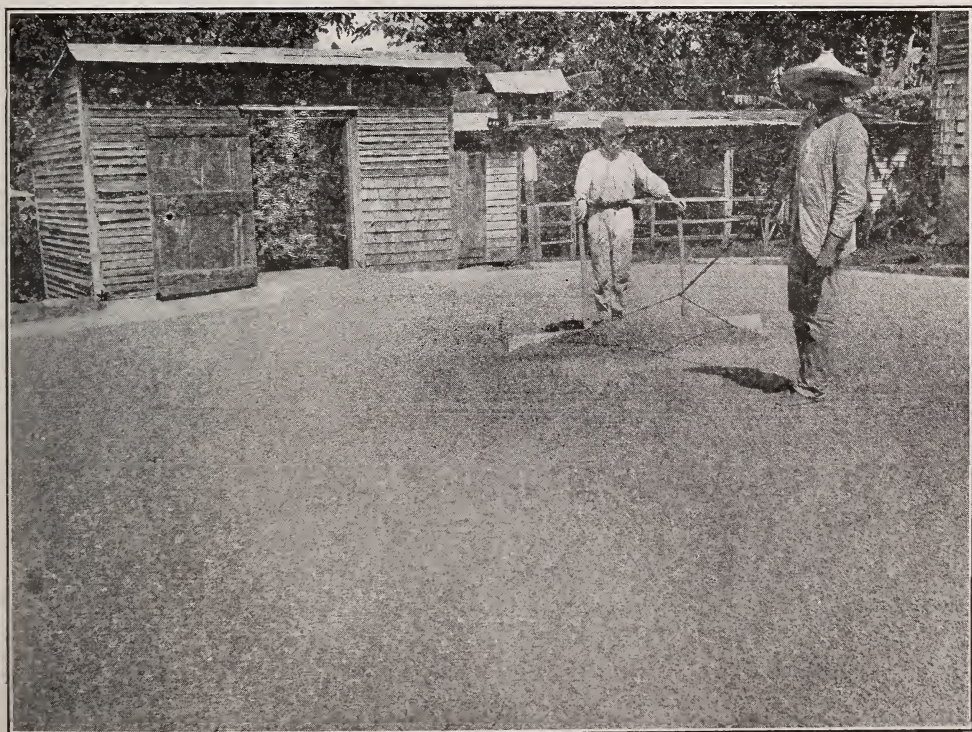


FIG. 2.—SPREADING COFFEE TO DRY ON PLAZA.





## REPORT OF THE COFFEE EXPERT.

By J. W. VAN LEENHOFF.

Storms during the last months of 1906 and in March, 1907, very dry weather during April, 1907, and abnormal heavy rainfall during May, 1907, followed by hail in September at the beginning of the harvest, were so many factors that influenced in making the coffee crop less abundant than last year's.

The bananas planted last year as provisional wind-breaks have now grown up and formed an efficient protection for the young coffee during the strong winds in the beginning of 1908. These provisional wind-breaks seem also to have greatly benefited the growth of the young permanent wind-breaks planted between the rows.

Of the insect pests, weevils have done much damage on the substation and surrounding plantations, especially at altitudes of about 2000 feet above sea level and over, mainly in the young coffee, several patches of which had the leaves and green parts of the twigs entirely gnawed off, and even young green berries were destroyed to some extent.

Borers are doing a great deal of harm to the guava shade trees in several important districts, in some cases entirely destroying them. During a visit to the Utuado and Coamo coffee districts hundreds of dead or dying shade trees were seen. In these same districts the coffee leaf blight is very apparent as shown by the numerous brown leaves hanging by shreds.

Coffee leaf miners, although everywhere abundant, seem to be kept in check by their parasite.

### IMPROVEMENT OF AN OLD COFFEE GROVE.

The yield this year, from a renovated coffee grove, was only 2,472 pounds as against 4,349 pounds in 1906-07. The blossoming of May, 1908, indicates, however, that the next crop will be much larger.

All former experiments were continued during the year.

### COST OF GATHERING AND PREPARING 100 POUNDS OF COFFEE READY FOR MARKET.

Cost of picking.....	\$ 1.40
“ “ field labor.....	2.55
Preparation for market .....	.75
Transportation from field.....	.20
“ “ plantation to Ponce.....	.37½
Total cost per 100 pounds.. ..	\$ 5.27½
Average price obtained per 100 pounds.....	\$ 11.23

## EXPERIMENTS WITH NEW PLANTINGS.

## COST OF PLANTING COFFEE IN PORTO RICO.

Expenses per acre for fourth year, 1907-08	
4 weedings, at \$2 .....	\$ 8.00
1 hoeing between rows .....	4.44
Total expenses fourth year.....	\$ 12.44

There was gathered in the 4th year 214 lbs. coffee produced by 2,416 young trees from 2 to 4 years old. and covering about 3 acres of land.

Per acre 71 lbs. coffee worth, at \$11.23 per 100 lbs.	\$ 7.97
Less cost of picking, preparing and transportation .....	2.73
Net cost per acre of coffee four years .....	\$91.56

The foreign coffees are doing very well and several are loaded with fruit.

*Coffea robusta*, a coffee variety which according to information is now attracting much attention in Java, is represented at the substation by 3 specimens.

One was top grafted on Porto Rican coffee and is doing finely, the graft having several fruits on it. One was top grafted on Maragogype and is also doing finely although yet without fruit. One was left in its original condition and is now a splendid young tree, which blossomed heavily this year, but hardly any fruit has set. Different other grafts with *Coffea liberica* as stock are doing finely and are bearing fruit.

The fields planted exclusively with Porto Rican coffee have improved considerably since the provisional wind-breaks have grown up, and are loaded with fruit.

Altogether the experiments have done well and results should begin to show at the end of this harvest.

The native method of drying coffee is shown in figure 2 of Plate IV.

## REPORT OF THE PLANT PATHOLOGIST.

By G. L. FAWCETT.

In beginning work at this station it was found desirable to obtain some knowledge as to the general conditions of the island with regard to plant diseases. In this study some of the agriculturally more important sections were visited and observations made on the presence and distribution of such diseases. More time was given to this because of the laboratory side of the work being hindered by a temporary lack of suitable equipment. Some of the results of this study are given in this report.

Among citrus fruits comparatively little disease was observed. The foot-rot is not uncommon in wet, poorly drained lands, but this is capable of control. Scab is quite common especially in young lemon trees. No cases of withertip were noted, nor of the physiological blight disease, so destructive in some other citrus growing regions; but as most of the budded groves are young, and only mature, fully bearing trees are subject to attack, its presence is hardly to be expected. The die-back due to overfeeding with organic nitrogen is not found in the citrus trees of Porto Rico at the present time; this may be because excessive applications of manures rich in such nitrogen have not been made.

The pineapple has one conspicuous disease characterized by the appearance of white spots on the leaves. This is caused in many cases at least by the entrance of organisms through wounds such as the punctures made by sucking insects. At first the spots are small and brown. Gradually they enlarge, the epidermis sinks, the interior tissue is destroyed, and the white bleached appearance is taken on. It is in no sense a serious disease although common under excessively moist conditions. Another disease of this fruit now being studied is characterized by a decay of the root system. This has been observed up to this time only in fields with stiff, impermeable soil. It is apparently favored by excessive rainfall. Not only the pineapple but many other fruits grown in soil of this nature are affected with root rot. The obvious remedy of not growing the plants on such soils cannot be resorted to for the reason that there are sections where comparatively large areas of clay land are found.

The sugar cane in Porto Rico is largely free from fungus diseases, and only in some places on the east coast, where the rainfall has been excessive, are they to be found in any abundance. The rind disease is much in evidence there, even where the plants are free from mealy bugs or other insects. Usually this disease follows the attacks of such insects. The canes in one field were found to be suffering much from the attacks of a



soil fungus. The fruits of an agaric-like fungus appeared in abundance on some of the dead stalks, but whether these are the fruits of the cane destroying fungus, is not yet determined. No other fruiting bodies were found. Slight attacks of the root disease were noticeable in many comparatively healthy fields in other parts of the island. The rind disease was also present to some extent in many of the fields. That both diseases are not more common is due in part to cultural methods now employed.

# REPORT OF THE ASSISTANT ANIMAL HUSBANDMAN.

By E. G. RITZMAN.

In the quality of live stock Porto Rico stands at the head of the West Indian islands. Formerly, large numbers were exported principally to the surrounding islands, but this exportation has gradually diminished in value.

The following table shows the number and value of live stock exported to foreign countries :

## EXPORTS OF PORTO RICAN LIVESTOCK.

YEAR.	HORSES AND MULES		CATTLE.	
	Number.	Value.	Number.	Value.
1901	4,143	\$ 118,694	12,829	\$ 457,938
1902	2,406	64,930	13,357	354,065
1903	1,540	32,114	11,273	291,650
1904	4,187	101,405	13,110	316,131
1905	2,574	73,917	8,185	206,655
1906	767	22,329	7,161	150,679
1907	104	6,586	215	4,071
1908	115	17,270	11	600

## HORSES.

The station has in previous reports emphasized the necessity of increasing the size of the native horses and mules. The native horses are small but possess much stamina. They are practically all of a saddle type and go very easy gaits, the most common of which is a racking pace; some of them, however, possess more stylish action; one gait is especially attractive, a fast rack with the high fore-feet action of a hackney. Horses possessing this gait are in demand and command high prices.

Some very good results have been obtained by several breeders in crossing imported saddle gaited and trotting bred stallions on native mares, with material increase in size.

Practically no horses are used for working in the fields, as they average too low in weight for that purpose, the greater number being probably under 800 pounds. Many horses are unsound. A very common defect easily noticeable is a knee-sprung condition. It results probably from being ridden too young and general hard usage on the macadam roads. Native mules are

also below the size to be used profitably for working in the fields. They are used mostly for pack animals. In hardiness they are the equal of native horses. By breeding American jacks to crossbred mares of good size some mules, now about yearlings, have been obtained which promise to be of good size.

The keep of horses and mules costs much less at the experiment station than in the States. Two horses receive 2 pounds each of oats per day, and two other smaller ones receive only 1 pound per day with Para grass for roughness. These horses, however, receive very little exercise. The mules, which are worked constantly on the road and in the fields, receive 3 pounds of oats daily with Para grass. This is less than one-third the amount of grain that would be fed to mules and horses of the same size in the States. Silage from Para grass has also been fed to the mules. When fed with about 1 liter of cane molasses diluted in water and sprinkled throughout they ate it with relish, but when molasses was not mixed with it they apparently cared little for it.

#### CATTLE.

The characteristics and merits of Porto Rican cattle have been sufficiently described in previous reports. The aim of the station has so far consisted in encouraging improvement in earlier maturity and a larger milk production. Unfortunately, the station has not been in a position to experiment along this line, but it is hoped that this can be undertaken in the near future, as large quantities of dairy products are at present imported and milk retails at exceptionally high prices. Improvement in more sanitary production and handling of milk is also desirable. Doubtless great improvement can be made by the use of good bulls from approved dairy breeds of cattle, but it would perhaps be better to introduce sires of such blood which more nearly resemble the native stock, as for example the Guernsey or Jersey. Some crossbred calves from Hereford bulls on native cows have been seen which resemble the Hereford in all characteristics, and as near as can be judged in young calves they promise to develop good beef types. One of the characteristics that crossbred animals seem to inherit from native stock is a very short, smooth coat in which it is more difficult for ticks to live.

The eradication of ticks from Porto Rico is an exceedingly difficult problem as they are constantly carried from one field to another by the work oxen. Spraying with a kerosene emulsion consisting of two gallons crude kerosene, one gallon of water and one-half pound of soap appears to be insufficient in killing ticks when applied with a spray pump. Live adult ticks which hatched larval ticks have been picked from a Shorthorn cow at this station one and two days after spraying.

Silage from Para grass mixed with a small portion of cowpeas has been fed to the cattle. The results were very unsatisfactory when they had access to green grass. They seemed to care little for it unless mixed with molasses and when no grass was fed, as was the case with the mules,



### SHEEP.

According to the census of 1899 the island possessed only 3,363 sheep. The sheep seen in this neighborhood and some seen in the hills between Ponce and Coamo, which doubtless represent fairly well those found in other parts, are large coarse animals of poor mutton type with a patchy, inferior fleece that would hardly shear 2 pounds. There is no reason why the cooler inland hills could not grow as good wool sheep, when properly handled, as the Merinos found in Spain. The continuous warm climate along the coast would probably be adverse to such an undertaking.

During the past year the station has obtained 5 ewes and 1 ram of African woolless sheep with the view to encourage the production of mutton, which is in great demand. They are a hardy breed, make good "rustlers," and should be admirably suited to native uses. They require comparatively little attention. Up to the present they have not been troubled with insect pests or parasites and no indication of foot rot has been noticed during the rainy period, as they are kept in a well drained paddock with access to a dry shed.

### GOATS.

Goats are much more numerous on the island than sheep. At present they undoubtedly furnish a large part of the meat that is sold for mutton as well as the milk for family use of the poorer classes. If any milch goats have ever been brought to the island they are now very much mixed with native stock. Canary island goats, which are good yielders, are said to have been brought in by one breeder, but they have not been kept pure. Native goats do not yield over 2 liters of milk daily. Owing to lack of system in breeding, the stock has very much deteriorated and it would therefore seem advisable to bring in some animals of a breed that would be adapted to this climate and give better results.

### HOGS.

Berkshires are the only breed kept by this station at present. They keep in good health, are thrifty and vigorous and appear to do well on the native grasses. They are also fed shorts, cornmeal, and tankage in the ratio of about four parts shorts, two of cornmeal, and one of tankage. A moderate amount of tankage is especially desirable for growing pigs, as no dairy by-products are available. Brood sows with pigs are given much range on which to forage with access to shade and fresh water.

## NOTES ON THE SOILS OF PORTO RICO.

By O. LOEW.

The luxuriant tropical vegetation observed in various parts of Porto Rico points to a favorable condition of the climate as well as of the soil. Nevertheless there exist in some of the cultivated soils some defects as investigations carried on at the experiment station have shown. Some were found to be so stiff as to obstruct growth and respiration of roots, some showed an acid and others an alkaline reaction, again others were found to contain an unhealthy excess of magnesia over lime. Nematodes were also found in tobacco seed beds as well as upon the roots of the coffee tree. Sometimes two or three unfavorable conditions combine in one place. In fact in one locality (Buena-ventura) a cane plantation was abandoned on account of decrease of returns.

In regard to the sufficiency of mineral nutrients it should be remembered that the same data can not be applied alike for northern and tropical lands. Even in spite of great deficiency of potash and phosphoric acid in soils, coffee, cacao and cotton can yield a fair growth in the Tropics, as Hébert<sup>a</sup> has reported from central and western Africa.

In loose, open soils the required percentage of the nutrients may, of course, be lower than in close soils, since in porous soils the roots can easily spread in every direction in search of the available necessary minerals. Detmer and Immendorff<sup>b</sup> reported in the best soils of Java a high content of available potash (0.24 per cent), phosphoric acid (0.16 per cent), and nitrogen (0.56 per cent). The soils of Porto Rico thus far analyzed at this station make a fine showing in this regard. In 6 samples of soil from cane land the amount of phosphoric acid was found to vary between 0.14 and 0.26 per cent, and in 16 samples from tobacco plantations there was only in 4 cases less than 0.1 per cent.<sup>c</sup> As to potash the former group of 6 soils showed 0.17 to 0.57 per cent, while 12 of the 16 samples of tobacco soils showed 0.11 to 0.47 per cent. Phosphatic and potassic fertilizers can, therefore, be dispensed with on most of these soils. However, small doses may be applied to the young plants when a rapid start is desired. The nitrogen content of the soil samples

<sup>a</sup> Quinz. Colon., 11 (1907), No. 4, p. 131.

<sup>b</sup> Botanische und landwirtschaftliche Studien auf Java. Jena, 1907, pp. 26-36.

<sup>c</sup> As to phosphoric acid, a special determination will be required to decide how much of it is firmly fixed in the humus in organic combination





FIG. 1.—*CROTALARIA RETUSA*,  
A NATIVE LEGUMINOUS PLANT.



FIG. 2.—MOLDS FOR CONSTRUCTING CEMENT FENCE POSTS.





from the cane land varied from 0.12 to 0.21 per cent, and in the samples from the tobacco land from 0.09 to 0.63 per cent. However, how much of this would be directly available can not be easily determined.

Opinions are still divided as to the minimum percentage of lime required for good returns. Some hold that 0.2 per cent lime in tropical countries is insufficient but this depends not only upon the close or open nature of the soil, but also upon the relative amount of magnesia present. The higher the magnesia content, the higher must be the lime content also. In regard to lime and magnesia the percentages vary considerably in the soils of Porto Rico.

In the western part of Porto Rico three types of soil may be recognized: (1) Very loose sandy soil containing sometimes fragments of marine shells, extending along the sea beach and bearing chiefly cocoanut palms. (2) A dark gray or black and very stiff clayey soil, extending from the base of the central mountain ranges to the sandy belt along the coast. It occupies lowlands and valleys and serves chiefly for cane plantations. (3) A loamy soil of intense red color, covering the hills and the mountain sides to a great extent. It is the product of disintegration of shale and a certain kind of trachyte and serves chiefly for culture of oranges, coffee, cacao, and bananas. This soil is not a so-called laterite soil,<sup>a</sup> observed frequently on the coast of tropical countries with moist climate.<sup>b</sup>

A detailed description of the characteristics of these soils will be possible after a greater number of analyses are available. Thus far it can be stated, however, that the soils of the second and third type show frequently an acid reaction on litmus paper. Such soils are capable of decomposing chlorids to some extent, absorbing the base and liberating hydrochloric acid.<sup>c</sup>

Now it is well known that certain plants, as barley and wheat, are very easily injured by acidity in the soil, while other plants, as potato and buckwheat, possess a certain power of resistance.<sup>d</sup> A weak acidity of soils is sometimes beneficial, e. g. when tertiary phosphates, as rock phosphate and bone dust, serve as manure. These are then more readily dissolved for the absorption by the roots. But in the majority of cases a neutral soil will be preferable,

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<sup>a</sup> These red soils, mostly poor in humus, occur widely spread in Porto Rico and are in most cases fertile. Since they further contain only very small amounts of free aluminium hydroxyd to judge from results obtained by treatment with cold potassa solution of 5 per cent and by cold hydrochloric acid of 1 per cent, these soils cannot be classed with the genuine laterites often found in the tropics but with the group of soils called tierra roja.

<sup>b</sup> The formation of this class of soils requires further study. As a rule, the laterite results from too much leaching by warm rains and shows an accumulation of ferric hydrate, aluminium hydrate, and silicates of both.

<sup>c</sup> Acid soils were found by Daikuhara to owe their acidity sometimes to certain zeolitic silicates.

<sup>d</sup> Maxwell mixed soils with 0.02 to 0.1 per cent citric acid and observed that cruciferous plants and clover rapidly perished in these mixtures. Wheat and barley, pea, vetch and lupin failed, maize developed flowers but no seed, only millet did well.

upon which phosphatic manure in the form of superphosphate will produce the best results. This is especially true for plants which develop at a rapid rate, as does tobacco, and demand, therefore, a most uniform distribution of the mineral nutrients within easy reach of the roots. Superphosphate, on account of its solubility, is capable of spreading through the soil, while ground rock phosphate is not. The "hygienic" conditions for the roots of tobacco must be as perfect as possible, stiff clay must be loosened, acid soils must be neutralized by carbonate of lime, alkaline soils must be neutralized by gypsum (in some rarer cases magnesium sulphate may also come into consideration), and in cases of a considerable excess of the magnesia content over the lime content in a soil, liming with addition of gypsum will become necessary.

Of 16 samples of soils from tobacco plantations, 9 were found by the chemist to be "acid," 5 "strongly acid," 1 "slightly acid," and only 2 samples were found of neutral reaction. The fact that the acid soils prevail in those districts may be chiefly due to the warm summer rains which easily leach out the carbonate of lime. On the other hand, lands of alkaline reaction are found in some districts where warm summer rains are reduced to a minimum.

Soils of an alkaline reaction are found in the southern part of the island which are not reached by the northern air currents. These currents deposit their moisture chiefly on the main mountain range of the central elevations, reaching an altitude of 4,000 feet, and thus the lowlands south of this range receive only a meager supply of rain. There exist, however, a number of creeks that furnish water for irrigation. But this water does not suffice for an occasional flooding of the plantation grounds as is practiced on the paddy lands for rice culture but only for moistening the soil so far as the development of cane would require. Under such a condition the carbonates of potash and soda, resulting from the disintegration of the rocky particles of the soil, accumulate and cause an alkaline reaction. This reaction is, however, unfavorable for several reasons. In the first place it is itself injurious and unnatural to the roots; in the second place, the roots are thereby prevented from dissolving lime, magnesia, and phosphoric acid at the required rate for growth; and in the third place, those alkalis render the clay soil of these lowlands very stiff and thus obstruct aeration and root growth indirectly. The writer has seen perfectly barren spots, devoid of a single blade of grass, convincing evidence of the alkaline reaction of that soil.

The chemist of the station has examined 6 samples of soils from the cane plantations of these localities and observed with 2 of them "alkaline reaction," with 3 a "strongly alkaline" reaction, and with 1 a "slightly alkaline" reaction.

The fact that this alkaline reaction had not been recognized before explains the reason why former expensive manuring experiments did not fulfill expectations. Indeed phosphatic and potassic manures are here not required, only nitrogenous ones. If superphosphate showed some beneficial effect it was probably due more to having neutralized to some extent the alkaline reaction than to the supply of phosphoric acid. Some of these



lands suffer from still another fault, they show an excess of magnesia over lime. The figures of 3 samples may be mentioned:

RELATION OF LIME TO MAGNESIA IN SOME PORTO RICAN SOILS.

	CaO	MgO
	Per cent.	Per cent.
Sample from Limon.....	2.89	4.27
Sample from Maria Antonia, No. 1.....	2.40	8.90
Sample from Maria Antonia, No. 2.....	5.20	9.98

In these cases a heavy application of gypsum will be of triple benefit, it will do away with the alkaline reaction, it will render the soil more open and will antagonize to a certain extent the evil influence of the excess of magnesia over lime.<sup>a</sup> This last mentioned condition was also observed with 14 of the 16 samples of tobacco land, and in half of these samples the magnesia content surpassed the lime content twofold and more. If this condition is found in soils of acid reaction, not gypsum alone, but slaked lime with addition of a certain amount of gypsum, should be applied, in order to correct the two defects as far as possible.

It will for these purposes be necessary to select a limestone free of magnesia or nearly free of it. Limestone samples from different parts of Porto Rico have shown a very low magnesia content, according to the chemist's analyses; one sample, however, from Quebradillas with 34 per cent of lime contained also 18.17 per cent of magnesia. Such a dolomitic limestone may be applied on soils which at the same time are poor in lime and in magnesia. Whether soils occur in Porto Rico which would show, besides a high lime content, so small a content of magnesia that magnesia alone should be supplied as a manure is thus far not known. In such cases a moderate manuring with magnesium sulphate would be in order.<sup>b</sup> In two of the samples of tobacco soils mentioned the lime content ran as low as 0.03 and 0.05 per cent, while the magnesia content amounted to 0.18 and 0.19 per cent, respectively. Liming will here prove of great benefit. There exist soils in Porto Rico which are much more benefited by liming than by the usual manuring, nitrogenous manure included, as an experiment with cane near this station has demonstrated. This soil suffers from three defects, viz., acidity, stiffness, and an excess of magnesia over lime. By the application of lime at the rate of 3,000 pounds per acre the yield of cane was increased 57 per cent. The yield that on the check plot was equal to 43.96 tons per acre was changed to the rate of 69.25 tons per acre by liming alone.

<sup>a</sup> The most favorable ratio of lime to magnesia in the soil for cane will very probably be as 2 : 1, if both are present in an equal state of availability. This can be inferred from experiments with maize by Bernardini.

<sup>b</sup> Crude sulphate of magnesia can be obtained at very low rates in Germany.

An experiment may here be mentioned which the writer proposed while in Tokyo, showing the powerful influence of lime on a soil that suffered from no other defect than an excess of magnesia (1.91 per cent) over lime (0.64 per cent). By adding 240 grams calcium carbonate to 10 kilograms of this soil, the yield of barley was just doubled.<sup>a</sup> Full mineral manure had also been applied.

In reviewing the observations thus far made at this experiment station on the soils of cane and tobacco plantations in Porto Rico it becomes evident:

(1) That these soils often show a very favorable percentage of potash and phosphoric acid.

(2) That doubtless various defects exist in these soils,<sup>b</sup> but they are of such a nature that they are easily remedied. Thus the outlook for increase of returns is a very favorable one.

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<sup>a</sup> Daikuhara, Bul. Imp. Cent. Agr. Exp. Sta. Japan 1, (1905), No. 1, pp. 13-16.

<sup>b</sup> On certain "sick" soils a special report will follow later on





